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Assessment of neglected areas in Vilnius city using MCDM and COPRAS methods

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Abstract

Based on the research carried out by foreign scientists, it has been established, that the so-called brown spots represent one of the key factors investors take into account in deciding upon their plans to pursue urban development. The focus of research on the subject of brown spots lies on the uncertainty as regards the indicators, based on which neglected areas shall be assessed. The presence of neglected urban space areas is a negative phenomenon, however, nowadays it is being successfully dealt with. Despite this, the number of newly emerging neglected areas exceeds the number of those that have been revived. The methods of reviving neglected areas, however, are targeted at dealing with problem consequences rather than at eliminating the problem itself. The social and economic context, under which countries have developed and now exist, differs, therefore, a single and universally accepted system of neglected area early indicators, that could be applicable to any country or city/town, does not exist. The authors of the present article discuss the questions of what should be avoided in order to prevent urban areas from becoming neglected during their life cycle, how to identify them in due time and how to avoid negative effects thereof. The authors have attempted to apply the idea of early indicators that has recently appeared in the scientific literature to the Lithuanian context, in this particular case to Vilnius city. Taking into account the outcomes of the previous research studies and the established hierarchy of indicators according to their significance within urban environment clusters, the authors have selected 15 most significant early indicators of neglected areas. Hence formed system of indicators may serve in practice as a basis for monitoring indicator data and tracking their changes. This system was applied for assessing Vilnius city elderates, collecting previously established early indicators of neglected areas and their numeric values and for using the attributive information contained in GIS databases of the Statistics Department of the Republic of Lithuania. The authors of the article applied MCDM method to determine the elderate of Vilnius city, wherein the future formation of neglected areas was most expected. The result thereof has been confirmed by the experts' inquest and COPRAS method.

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1. Introduction

Neglected area is an internationally accepted term used to refer to herein analysed issue. This term defines a certain issue of urban development which often takes the form of uncontrolled periphery bound spread of urban carcass. [1].. This phenomenon directly affects the life of city residents in terms of its quality and has a damaging environmental, economic and social impact. No common definition of brown spots and no common understanding as for how neglected, dysfunctional and convertible territories in the member states of the European Union (hereinafter ES) should be treated have been established so far.

Based on the research carried out by foreign scientists, it has been established that neglected areas represent a key factor determining investors' plans to pursue urban development goals. The prevailing key problem is the lack of information on how neglected areas should be assessed. A comprehensive geostatistical and qualitative analysis of the research on the subject of neglected areas, the results whereof would provide objective conclusions on how to integrate them into the urban carcass of a city/town and hence control its socio-urban, cultural and economic environment, so far has not been carried out in Lithuania.

The countries of Central Europe encounter shared problems in dealing with the issue of neglected areas. Therefore, the authorities responsible for a cohesive urban development often become interested in sharing good practice and learning from the mistakes made. Among frequently encountered challenges are the preservation of cultural heritage, the unwillingness of investors to invest into damaged land, the problems of environmental pollution, the identification of common problems and other phenomena making influence on urban environment and the quality of life of therein residing people.

In Lithuania, larger-scale processes of territory conversion started after the restoration of state independence, when the directions of urban development were determined by private capital [1, 2]. With the recovery of construction sector during the pre-crises period, which started in 2005, the scope of construction works in the cities of Lithuania had increased tenfold. At that time, planning efforts were mainly focused on the areas of residential apartment blocks and commercial buildings. [3]. Due to such deformational changes, the areas within cities started suffering abandonment and became no longer able to perform their initial functions. Thus, these and the adjacent areas have lost their attractiveness to new investments, while regeneration projects in these areas are avoided due to expensiveness of land in these areas and high costs of building them up and, therefore, are undertaken only in exceptional cases.

As pointed out by M. Pakalnis [4] one of the key factors making influence on the formation of urban wasteland areas is related to demographic changes [5]. Depopulation leads to the unwillingness of citizens to take an active part in the processes of city planning and their critical assessment. The demographic changes have led to the situation, where previously used public infrastructure is no longer exploited due to the distortions of urban landscape, abandonment of cities and uncontrolled processes of suburbanization. Issues related to the reconstruction and revival of areas are raised only in individual cases and most often at the time when dissatisfaction over the existing situation reaches its critical point.

The authors assessed the reasons behind the formation of neglected areas and established a hierarchic scheme of indicators defining neglected areas. Since the selected indicators are multicriteria, they all have been classified by the type of impact they make. The methods applied enabled the authors to estimate the significance values of these indicators. From the entire set of indicators there were selected the most significant ones, based on which the assessment of neglected areas, as a phenomenon in a heterogeneous urban space, could be carried out..

2. Review of foreign researches

The available scientific literature contains numerous descriptions of methods applied in the research of processes aimed at reviving neglected areas and these descriptions generally cover one or more weighted indicators. Most frequently found indicators include the following:

- risk evaluation [6-8];
- prevailing policy [9];
- optimization of reconstruction [10-12];
- evaluation of revival costs;
- general factors of successful revival [13];
- development of infrastructure [16];
- urban planning and allocation of land plots in line with budgetary capabilities [17, 18];
- mediation in stakeholder negotiations [19].

The transformation of society from industrial to post-industrial witnessed in Europe resulted in major changes in the legal systems of countries and made a significant impact on the traditions of territorial planning. The legal systems became irresistible to the impact on the spatial structure of cities/towns exerted by private capital, while the responsible authorities in charge of regulating these processes lacked experience in controlling this urbanization process.

Compared to other European countries, Lithuanian architects, municipalities and those in charge of urban planning lack an integrated approach to the processes of urban development and to the need to make it balanced and eco-friendly [20]. The analysis of scientific literature and territorial planning and the associated official documents carried out by the authors is mainly focused on the experience of countries from Western Europe and post-soviet states from Central Europe, since it has more historical relevance to the transformation processes in the Lithuanian political context, business sector and territorial planning culture.

Having analysed the guidelines for management of territories published in foreign scientific literature and in the European network of experts [21], the authors of the present study have indicators, based on which neglected and unused urban areas are identified in different European countries. The examination of neglected and unused area definitions published by 16 European countries has revealed that most frequently mentioned indicators include the purpose of land use (22.8 %), the equipment of engineering infrastructure (15.8 %) and the environmental pollution (12.3 %). The definitions of brown spots and the research methods applied in the European countries, wherein, as pointed out by the experts, neglected areas pose the biggest threat to the balanced process of urban development and the quality of life, are presented in Table 1 [21] below. The section on research methods provides summaries of methods each country applies in carrying out the research of neglected areas.

Table 1. Comparison of definitions and applied research methods of brownfields in different European countries

No.	Country	Definition	Applied methods of researches
	Austria	Official definition is not available. Unofficial understanding is similar to the definition adopted by CABERNET (Concerted Action on Brownfield and Economic Regeneration Network), which provides a description of areas that may be reused with less focus on pollution threats..	Geostatistical analysis
	Belgium (Wallonia)	Land plots, the use whereof once had the effective economic purpose, but now is considered to be „contrary to the effective use of land".	Satellite analysis
	Belgium (Flanders)	Neglected and previously unused areas, that still have an active potential for being reconstructed or expanded, but these possibilities are limited by potential/actual threats of pollution.	Life cycle analysis
	Bulgaria	Polluted areas, i.e. areas, wherein previously conducted activities have been already terminated, but the effects of such activities are still being felt in the adjacent areas.	Pollution analysis
	France	Previously developed, but now open space that is not being actively used on a temporal or permanent basis and needs to be restored to meet future needs.	Cultural heritage studies
	The Netherlands	Areas within cities and towns, wherein previously carried out industrial	Urban sprawl researches

		activities now are terminated, leaving the area unused.	
.	Romania	Contaminated land (soil, ground).	Spatial analysis for decision-making
	Slovenia	Degraded land or land of neglected buildings generally located in urbanized city areas.	Soil pollution analysis
	Spain	Plots of potentially contaminated land. Ruins of industrial buildings.	Geostatistical analysis
	England and Wales	Previously developed land, i.e. a plot of land that now is or previously has been a permanent build-up structure (except for extensions and buildings belonging to agricultural or forestry sectors), to be linked with the fixed surface infrastructure.	Comparative analysis between different countries

One of the most recent studies on the subject of issues related to neglected areas, carried out by Belgium and Dutch scientists Beames, Broekx, et al. [22], is focused on life-cycle assessment. Though the authors selected only one 2 ha area in Belgium, they managed to assess a set of environmental indicators and evaluate alternatives in a complex manner by applying a single system of assessment. Whereas in Romania, decisions in assessing the alternatives of using neglected areas were made based on the results of spatial analysis carried out by applying GIS technology [23]. German researchers suggest that the issues of neglected areas should be assessed through the establishment of combinations between the type of site prevailing purpose and the indicators of a neglected area within the site [24].

Despite the abundance of scientific articles and local studies providing on overview of the subject in question, information on the methods of establishing indicators that define the issue of brown spots is lacking in the present-day scientific literature. Failure to define and subsequently assess these parameters results in maximized risk that the processes of reviving neglected areas will not justify the objectives set and, therefore, poses threat to the heterogeneous urban environment and the quality of life. There is a lack of complex multisectoral assessment that would enable establishing a hierarchy of indicators by each country‘s priorities, set goals and available possibilities. The multicriteria quantitative assessment of indicators suits this purpose, provided that the selection of indicators is conducted in a complex manner and by involving top-ranked specialists possessing expertise of the highest degree.

3. Expert evaluation method

The authors performed the analysis of expert evaluation based on the significance parameters of indicators defining neglected areas. The established system of indicators has allowed the identification of primary, secondary and the key indicators, the numeric values whereof most objectively reflect the current state of neglected areas, their potential and detrimental impact and, thus, provide the possibility to envisage the most rational scenario of conversion.

3.1. Experts

The experts in charge of evaluating the questionnaire drafted by the authors were selected based on following criteria:

- over 5 years‘ practical expertise in territorial planning, social, economic, environmental and engineering areas;
- higher education degree in the areas of engineering, economy, real property management, ecology and heritage protection;
- persons currently working in any of the above mentioned areas.

The questionnaires were delivered to employees of municipalities in charge of territorial planning, drafters of project parts, representatives of non-profit organizations and experienced specialists in the area of environment and heritage protection holding the respective qualification certificates. The authors defined the areas, to which attributed indicators had to be evaluated by experts, taking into account the analysis of foreign scientific literature:

- urban economic environment;
- urban social environment;

- city engineering infrastructure, urban carcass;
- urban natural and ecological environment.

Totally 10 experts were involved in the completion of questionnaires in accordance with their respective areas of work. The authors verified the compatibility of their opinions and had concluded that they were mutually compatible. This allowed the authors to pick up from the original set of indicators the most significant ones.

3.2. Indicators

The analysis of expert opinions allowed the most significant early indicators of neglected areas to be sorted out. The authors evaluated these expert opinions taking into account their previous investigations [25] and produced a list of most significant indicators. Each of these indicators was evaluated by determining its rank and calculating its subjective significance Q_j [26-32]. Selected indicators are represented at Table 2.

Table 2. Calculated the most significance indicators (Final indicators) in each group of indicators

Group of Economic indicators	Group of Social indicators
• ratio between property price in the municipality and the neighbouring municipalities (Q_j = 0,079);	• permanent unemployment level (Q_j = 0,098)
• value of real property (Q_j = 0,085)	• percent share of population living below the poverty threshold (Q_j = 0,099)
• investments (in the private and public sectors) (Q_j = 0,099)	• actual average income of population (Q_j = 0,093)
• spatial mismatch between employees and workplaces (Q_j = 0,078)	• level of crime (Q_j = 0,093)
Group of Urban indicators	**Group of Natural indicators**
• area of vacant land plots (Q_j = 0,082)	• level of soil (ground) contamination (0,112)
• number of new planning permissions (0,072)	• emissions from local pollution sources (0,115)
• lifetime of installed infrastructure elements (0,074)	• amount of green zones per inhabitant (0,126)
	• level of pollution by emissions from transport mean (0,105)

The authors have determined that the theoretical model of the most significant indicators that define the issue of neglected areas largely corresponds to the social, economic, historical, cultural and urban climate not only in Lithuania, but also in the countries formerly occupied by the Soviet Union (e.g. Czech Republic, Slovakia, Romania, etc.) [33-38].

4. Indicators selection using the relative values

4.1. The amount of data and relatives values

The zone of determining relative values of the selected indicators covers the city of Vilnius (410 km2, see Figure 1) and its peripheral zones. As determined by the authors, Vilnius contains 906,4 ha of neglected areas and it represents 2,21 % of the total Vilnius city territory. The majority of neglected areas are located in non-urbanized zones of the city. These are open and polluted wasteland areas free of any social and engineer infrastructure.

Over the recent decade, the administrative boundaries of Vilnius city have been expanded by 4518.9 ha (11,7 %) of the total city territory. With those areas being joined, the city development has taken northward and westward directions. The spatial distribution of urban brownfields in city of Vilnius is represented at Figure 1.

4.2. Collection of spatial data

Collection of spatial data was performed by the authors by applying GIS technology. This combination is used for identifying and selecting the areas investors may deem to be attractive according to the environmental, ecological, build-up and infrastructure as well as social criteria.

The research was carried out using the most recent sets of official data. The data containing the attributive information are stored in shapefiles. The attributive information is related using the method of spatial join. This method allows the data to be classified by spatial distribution and normalized by multiple statistic information.

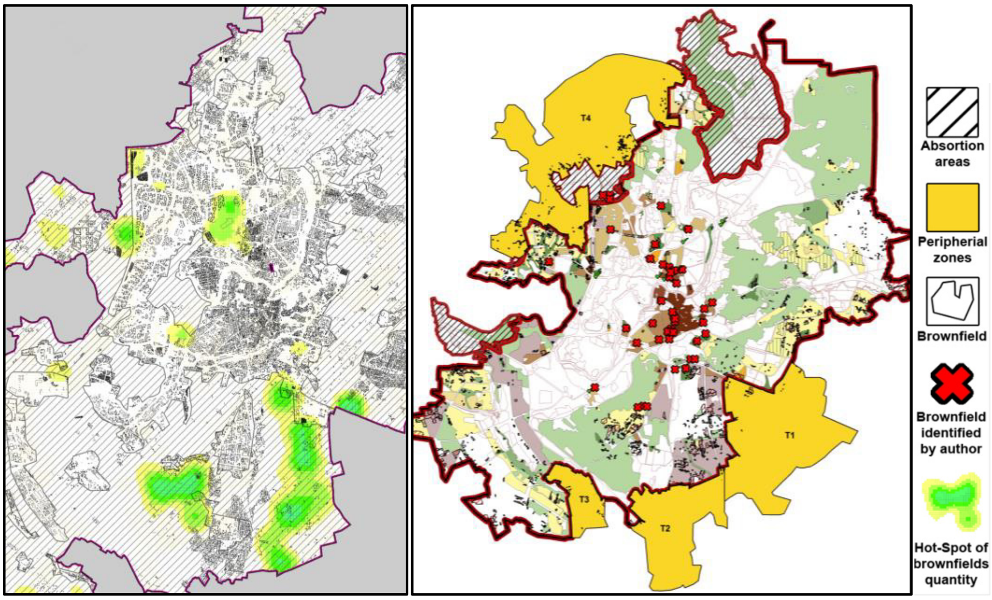

Figure 1. Distribution of urban brownfields in city of Vilnius (on the left) and including peripheral zones (on the right)

For the purpose of calculating the relative values of indicators, the census data of the Department of Statistics for 2012 were used. It is a set of information containing data on population density, household indicators, social and demographic environment. These data are presented on a shapefile in the form of a 100 x 100m grating. Such precision of gratings enables the accurate performance of spatial join and spatial relationship operations taking into account the administrative boundaries and the location of elderates.

4.3. Selection of alternative indicators in the case of city of Vilnius

Using publicly accessible databases of statistic information, the authors derived the relative values of indicators. These values were normalized by the number of population in each elderate. The relative indicators per each Vilnius city elderate that have been derived from the most significant indicators selected by using the theoretical model are presented in Table 3 below.

Table 3. Alternative final indicators of brownfields

		Group of Economic indicators:	
E_{a1}	min	ratio between property price in the municipality and the neighbouring municipalities;	ratio between assigned investment to the municipality and neighbouring municipalities (thousand of Euros)
E_{a2}	max	value of real property	average of construction costs (thousand of Euros
E_{a3}	max	investments (in the private and public sectors)	Approved appropriations for implementation of urban strategy (thousand of Euros)
E_{a4}	min	spatial mismatch between employees and workplaces	Data of Vilnius Master plan. Difference between excess and shortage of workplaces (units).
		Group of Urban indicators:	
U_{a1}	min	area of vacant land plots	Area of vacant and damaged land (ha)
U_{a2}	max	number of new planning permissions	number of residential living objects (units/100 inhabs.)
U_{a3}	min	lifetime of installed infrastructure elements	average years of built of residential buildings
		Group of Social indicators	
S_{a1}	min	permanent unemployment level	ratio between number of unemployed population and working-age population (%)
S_{a2}	min	percent share of population living below the poverty threshold	percent of population on average receiving less income than poverty threshold (%)

S_{a3}	max	actual average income of population	average income of persons receiving income from outsourced activities (€)
S_{a4}	min	level of crime	number of public crimes per 1000 inhabitants
		Group of Natural indicators:	
N_{a1}	min	level of soil (ground) contamination	total indicator of pollution (Zd)
N_{a2}	min	emissions from local pollution sources	average amount of NO_2 per 1 year (μg/m^3)
N_{a3}	max	amount of green zones per inhabitant	Total area of forest, scrubs and other greenfields per 100 inhab. (ha)
N_{a4}	min	level of pollution by emissions from transport mean	dissemination of Nitrogen oxides from vehicles (μg/m^3)

In Table 3, *min* and *max* refer to whether the value of the indicator shall be maximized or minimized, taking into account the issue of neglected areas: causes, consequences and other peculiarities.

Further, the authors estimated the most significant indicators per elderate based on the established measure units. Hence obtained matrix may be applied in assessing and comparing, in terms of neglected areas, the state of elderates using such multicriteria assessment methods as TOPSIS, COPRAS, SAW or the correlative analysis.

5. Application of COPRAS method

Having performed the analysis of different multicriteria assessment methods, the authors further applied COPRAS method. COPRAS method was developed in 1996 by Vilnius Gediminas Technical University scientists Zavadskas and Kaklauskas [39] and first published in a respective article [40].

The essential principle of the method lies in the possibility to combine values r_{ij} of all indicators R into a single qualitative account, i.e. the value of method criterion. COPRAS method-based calculations are performed using the classical normalization under formula 1.

$$\widehat{r_{ij}} = \frac{r_{ij}}{\sum_{j=1}^{n} r_{ij}}, (i = 1, \ldots, m; j = 1, \ldots, n; \sum_{j=1}^{n} \widehat{r_{ij}} = 1). \quad (1)$$

This method assumes direct and proportional dependence of priority and utility degree of study alternatives on the system of indices adequately describing the alternatives as well as on values and significances of indices. Calculations were made in four steps. The first one is:

$$d_{ij} = \frac{r_{ij} \cdot \omega}{\sum_{j=1}^{n} r_{ij}}, \ i = \overline{1,m}; \ j = \overline{1,n} \quad (2)$$

where r_{ij} is the value of the i-th criterion in the j-th alternative of a solution; m — the number of criteria; n — the number of compared alternatives; q_i — significance of the i-th criterion.

Step 2. Calculate the sums of weighted normalized indexes describing the j-th version. The versions are described by minimizing indexes S_{-j} and maximizing indexes S_{+j}. The lower value of minimizing indexes is better as well as the greater value of maximizing indexes. The sums are calculated according to the formula 3:

$$S_{\pm j} = \sum_{i=1}^{m} d_{\pm ij}, \ i = \overline{1,m}; \ j = \overline{1,n} \quad (3)$$

Step 3. Determine the significance of comparative versions on the basis of described characteristics of positive (“pluses”) and negative (“minuses”) alternatives. The relative significance Q_j of each alternative a_j is found according to the formula 4:

$$Q_j = S_{+j} + \frac{S_{-\min} \cdot \sum_{j=1}^{n} S_{-j}}{S_{-j} \cdot \sum_{j=1}^{n} \frac{S_{-\min}}{S_{-j}}}, \ j = \overline{1, n} \tag{4}$$

Step 4. Determine the priority of alternatives. The higher is Q_j, the higher is the efficiency (priority) of the alternative.

Table 4 contains a matrix of decision making with the values of indicators to be calculated for each Vilnius city elderate in question.

Table 4. The matrix of Alternative final indicators of brownfields in the context of city of Vilnius

	A_1	A_2	A_3	A_4	A_5	A_6	A_7	A_8	A_9	A_{10}	A_{11}	A_{12}	A_{13}	A_{14}	A_{15}	A_{16}	A_{17}	A_{18}	A_{19}	A_{20}
E_{a1}	1.2	1.0	1.0	1.0	1.0	1.2	1.0	0.5	1.0	1.0	1.0	1.0	1.2	1.0	1.0	1.0	1.0	1.0	1.0	1.2
E_{a2}	1.5	1.2	1.2	1.2	1.2	1.5	1.2	0.7	0.7	1.2	1.2	1.2	1.5	1.2	1.2	1.2	1.2	1.2	1.2	1.5
E_{a3}	52	50	50	50	50	50	67	52	50	50	49	49	49	50	49	52	49	49	50	49
E_{a4}	-3	-28	-30	-27	-25	38	1.4	-19	10	-13	-7	-4	4	-19	-4	4	6	-24	-6	3
U_{a1}	0.2	0	0.0	0.0	0.1	0	0.3	0.2	2.3	0	0.6	0.5	0	0.2	0	0.1	0	0	0	0
U_{a2}	8.0	0.7	0.5	0.5	1.2	0.6	7.0	13	31	0.7	1.5	12	0.9	0.7	3.5	3.4	3.2	0.7	0.6	4.0
U_{a3}	70	82	84	71	81	48	62	65	66	77	77	51	37	71	47	77	63	74	61	50
S_{a1}	10	5	3	6	3	4	8	11	19	5	6	12	7	4	6	6	4	4	3	8
S_{a2}	21	3	1	6	12	7	17	27	40	0	12	23	14	1	7	6	6	6	5	15
S_{a3}	0.4	0.4	0.4	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.4
S_{a4}	236	11	6	16	41	64	213	164	396	10	51	92	64	18	21	57	74	13	20	9
N_{a1}	10	4	2	2	2	18	7	10	7	2	2	4	8	3	5	8	5	2	7	3
N_{a2}	22	19	16	19	27	55	23	12	29	31	12	17	36	29	29	10	20	38	40	31
N_{a3}	14	0	0	1	2	0	4	4	37	0	2	7	0	0	0	3	2	0	0	0
N_{a4}	0	0	0	0	0	11	38	0	16	0	0	8	16	1	1	2	7	0	0	0

These calculations show that formation of neglected areas, as assessed in accordance with the predefined early indicators, is most likely in Paneriai (Qj = 0,084), Verkiai (Qj = 0,060) and Vilkpėdė (Qj = 0,055) elderates, whereas in Senamiestis (Qj = 0,036), Naujininkai (Qj = 0,037) and Naujoji Vilnia (Qj = 0,043) districts it is least probable.

Hence there has been obtained a series of priorities reflecting the state of all Vilnius city districts in question in line with the relevance of the predefined early indicators (see Table 5).

Table 5. Ranks of districts of Vilnius city according to satisfaction of early indicators

Municipality	Panerių	Verkių	Vilkpedės	Žvėryno	Antakalnio	Pašilaičių	Šnipiškių	Pilaitės	Rasų	Žirmūnų	Justiniškių	Šeškinės	Fabijoniškių	Naujamiesčio	Karoliniškių	Viršuliškių	Lazdynų	Naujosios Vilnios	Naujininkų	Senamiesčio
A_i	A_9	A_{16}	A_{17}	A_{20}	A_1	A_{10}	A_{15}	A_{11}	A_{12}	A_{19}	A_3	A_{14}	A_2	A_6	A_4	A_{18}	A_5	A_8	A_7	A_{13}
Rank	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20

Values of relative significance Qj for each district of city of Vilnius are represented at Figure 2.

Residential blocks, however, require a special and more in-depth analysis. For instance, in Perkūnkiemis, neglected areas cover a relatively large area (as much as 5.18% of the territory being developed), however, public green spaces and other public infrastructure specific to residential blocks is not envisaged under the solutions of Vilnius City Master Plan. Thus, there is a conflict between the actual and the planned purpose of territory use. Evaluation of this conflict requires an additional geostatistical analysis based on herein presented findings of the research.

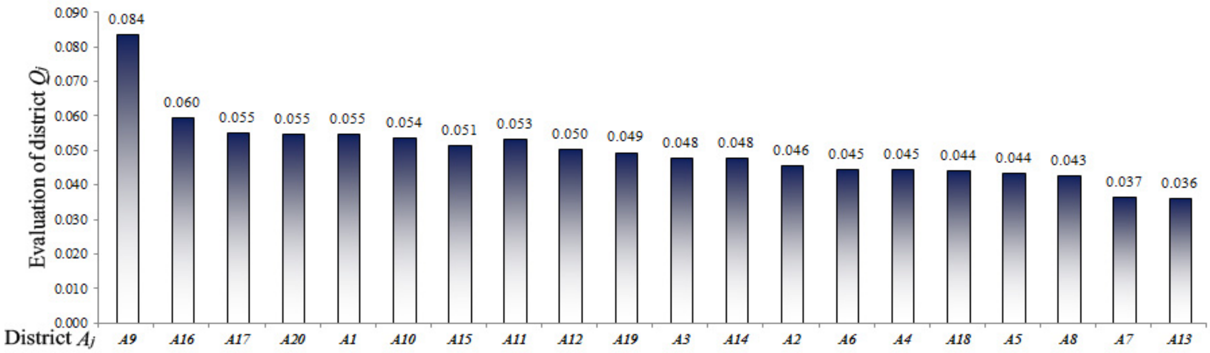

Fig. 2. Values of relative significance Q_j for each district of city of Vilnius

6. Conclusions

1. The authors of the present work have performed the analysis of foreign scientific literature, the results whereof show that the issue of neglected areas may be defined in terms of indicators with measurable normative values. In Europe, the multicriteria assessment of indicators using quantitative methods so far has not been performed.
2. The authors have carried out the quantitative assessment using the multicriteria MCDM method and determined the significance of indicators. The calculations performed have revealed that the most significant indicators defining neglected areas include investments (in the private and the public sectors), the value of real estate, the percent share of population living below the poverty threshold, the permanent unemployment level, the area of vacant land plots, the lifetime of the existing infrastructure, the number of green zones as well as air pollution and soil contamination at the local level.
3. The highest correspondence to the predefined early criteria have shown Paneriai, Verkiai and Vilkpėdė elderates, therefore, it is most likely that neglected areas will emerge namely therein; whereas the lowest correspondence to the above-mentioned criteria have proved to bear the elderates of Senamiestis, Naujininkai and Naujoji Vilnia, where the formation of neglected areas is least expected.
4. The assessment of indicators carried out by the authors may be used as a leverage providing the possibility to design scenarios of converting neglected areas under different economic, social, urban and environmental conditions.

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